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2023JCS2561

Learning switch

The provided code is a Python script for a Ryu application, which is a software-defined networking (SDN) controller framework. Based on the OpenFlow protocol version 1.3.

Overview:
The script defines a class SimpleSwitch13 that inherits from app_manager.RyuApp, making it a Ryu application.It handles OpenFlow messages to implement a basic layer 2 switch functionality.

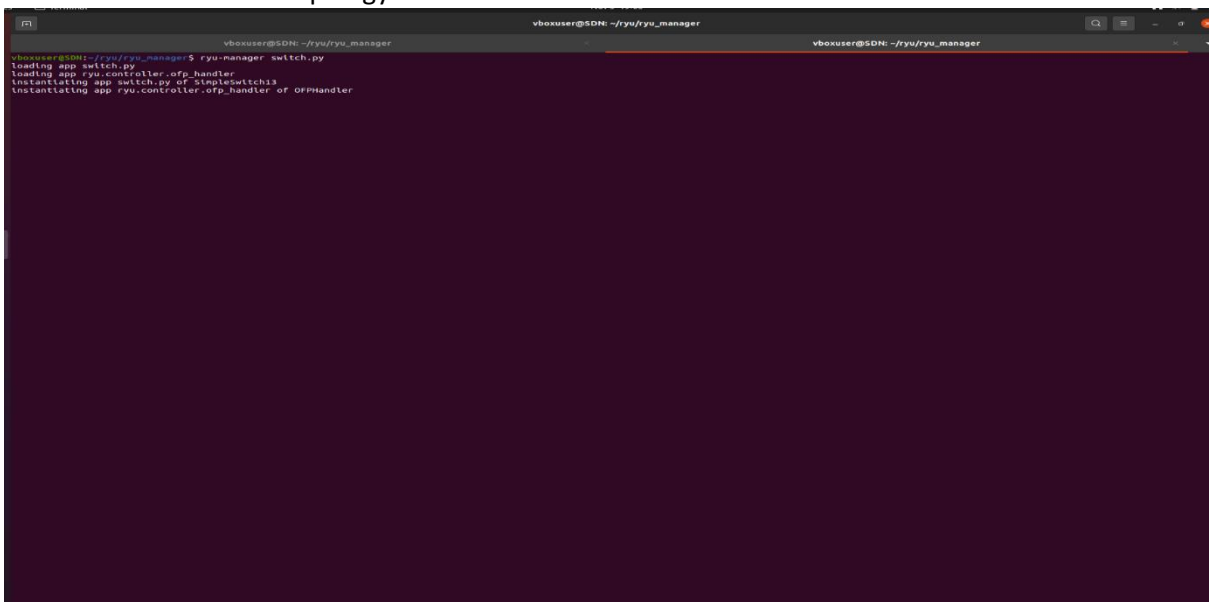
Initialization:
The class initializes by creating a dictionary mac_to_port to store MAC addresses and corresponding switch ports.

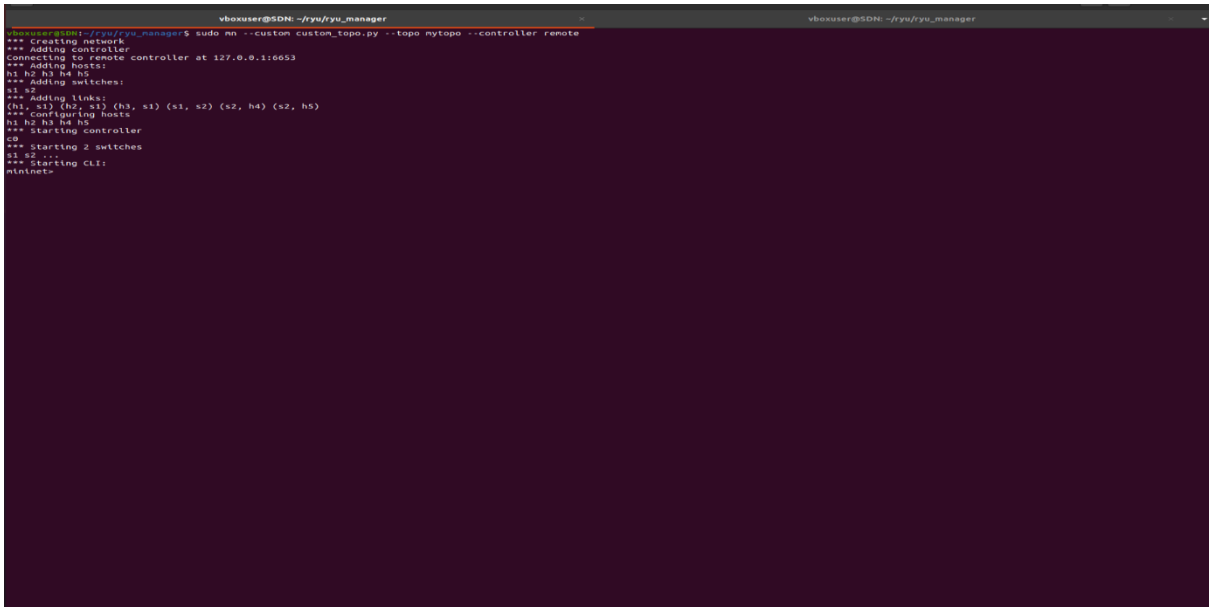
switch_features_handler:
This method is an event handler triggered when a switch connects to the controller.It configures the switch to send packets to the controller for unmatched flows.

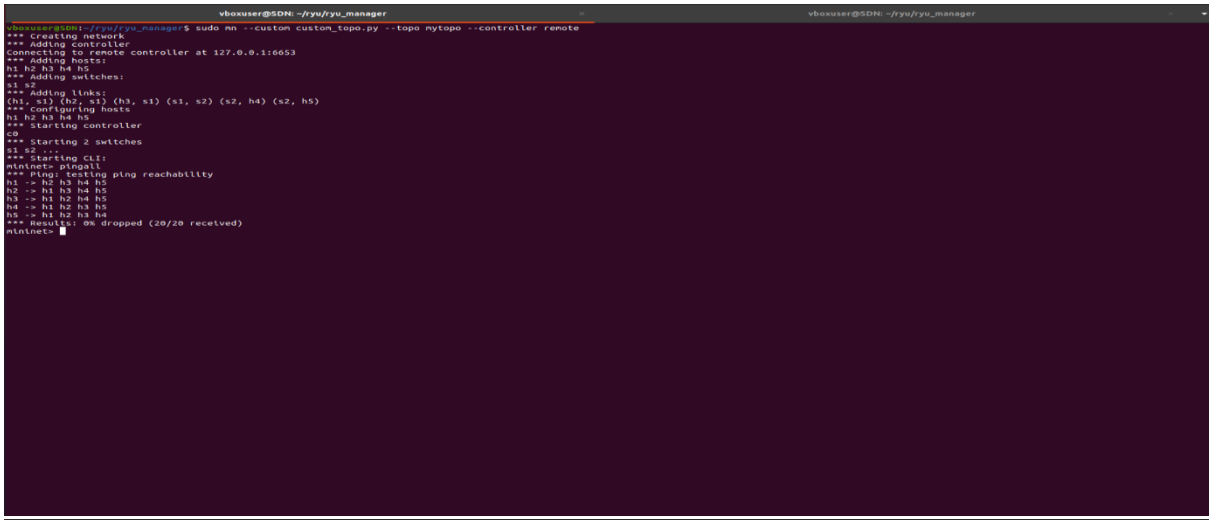
add_flow:This method adds flow entries to the switch's flow table.It constructs flow modification messages based on the provided match criteria, actions, and priority.

_packet_in_handler:This method is an event handler for packet-in messages, which occur when a packet reaches the controller.It learns MAC addresses and associated ports, then determines the appropriate output port for the incoming packet.If the destination MAC address is already known, it installs a flow entry to avoid further packet-in messages for similar packets.If the destination MAC address is unknown, the packet is flooded to all ports except the incoming port.

Screenshot attached of topology and controller.




vboxuser@SDN: ~/ryu/ryu_manager
vboxuser@SDN: ~/ryu/ryu_manager
vboxuser@SDN:~/ryu/ryu_manager$ sudo mn --custom custom_topo.py --topo mytopo --controller remote
*** Creating network
*** Adding controller
Connecting to remote controller at 127.0.0.1:6653
*** Adding hosts:
h1 h2 h3 h4 h5
*** Adding switches:
s1 s2
*** Adding links:
(h1, s1) (h2, s1) (h3, s1) (s1, s2) (s2, h4) (s2, h5)
*** Configuring hosts
h1 h2 h3 h4 h5
*** Starting controller
c0
*** Starting 2 switches
s1 s2 ...
*** Starting CLI:
mininet>


vboxuser@SDN: ~/ryu/ryu_manager
vboxuser@SDN: ~/ryu/ryu_manager
vboxuser@SDN:~/ryu/ryu_manager$ sudo mn --custom custom_topo.py --topo mytopo --controller remote
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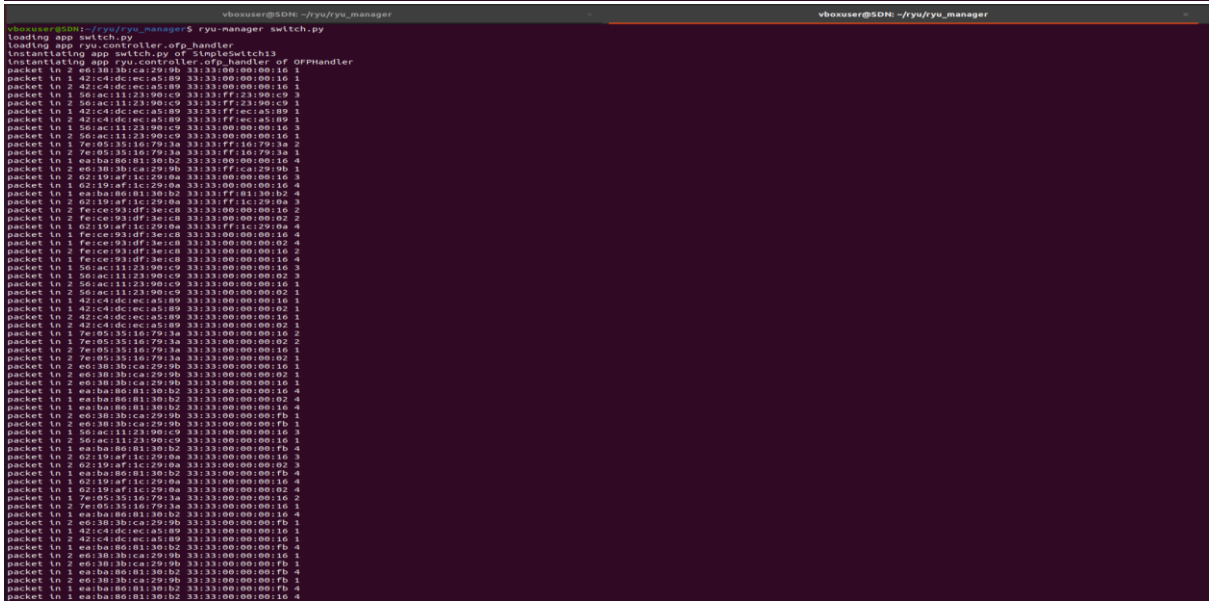
*** Configuring hosts
h1 h2 h3 h4 h5
*** Starting controller
c0
*** Starting 2 switches
s1 s2 ...
*** Starting CLI:
mininet> pingall
*** Ping: testing ping reachability
h1 -> h2 h3 h4 h5
h2 -> h1 h3 h4 h5
h3 -> h1 h2 h4 h5
h4 -> h1 h2 h3 h5
h5 -> h1 h2 h3 h4
*** Results: 0% dropped (20/20 received)
mininet>


vboxuser@SDN: ~/ryu/ryu_manager
vboxuser@SDN: ~/ryu/ryu_manager
vboxuser@SDN:~/ryu/ryu_manager$ ryu-manager switch.py
loading app switch.py
loading app ryu.controller.ofp_handler
instantiating app switch.py of SimpleSwitch13
instantiating app ryu.controller.ofp_handler of OFPHandler
packet in 2 e6:38:3b:ca:29:9b 33:33:00:00:00:16 1
packet in 1 42:c4:dc:ec:a5:89 33:33:00:00:00:16 1
packet in 2 42:c4:dc:ec:a5:89 33:33:00:00:00:16 1
packet in 1 56:ac:11:23:90:c9 33:33:ff:23:90:c9 3
packet in 2 56:ac:11:23:90:c9 33:33:ff:23:90:c9 1
packet in 1 42:c4:dc:ec:a5:89 33:33:ff:ec:a5:89 1
packet in 2 42:c4:dc:ec:a5:89 33:33:ff:ec:a5:89 1
packet in 1 56:ac:11:23:90:c9 33:33:00:00:00:16 3
packet in 2 56:ac:11:23:90:c9 33:33:00:00:00:16 1
packet in 1 7e:05:35:16:79:3a 33:33:ff:16:79:3a 2
packet in 2 7e:05:35:16:79:3a 33:33:ff:16:79:3a 1
packet in 1 ea:ba:86:81:30:b2 33:33:00:00:00:16 4
packet in 2 e6:38:3b:ca:29:9b 33:33:ff:ca:29:9b 1
packet in 2 62:19:af:1c:29:0a 33:33:00:00:00:16 3
packet in 1 62:19:af:1c:29:0a 33:33:00:00:00:16 4
packet in 1 ea:ba:86:81:30:b2 33:33:ff:81:30:b2 4
packet in 2 62:19:af:1c:29:0a 33:33:ff:1c:29:0a 3
packet in 2 fe:ce:93:df:3e:c8 33:33:00:00:00:16 2
packet in 2 fe:ce:93:df:3e:c8 33:33:00:00:00:02 2
packet in 1 62:19:af:1c:29:0a 33:33:ff:1c:29:0a 4
packet in 1 fe:ce:93:df:3e:c8 33:33:00:00:00:16 4
packet in 1 fe:ce:93:df:3e:c8 33:33:00:00:00:02 4
packet in 2 fe:ce:93:df:3e:c8 33:33:00:00:00:16 2
packet in 1 fe:ce:93:df:3e:c8 33:33:00:00:00:16 4
packet in 1 56:ac:11:23:90:c9 33:33:00:00:00:16 3
packet in 1 56:ac:11:23:90:c9 33:33:00:00:00:02 3
packet in 2 56:ac:11:23:90:c9 33:33:00:00:00:16 1
packet in 2 56:ac:11:23:90:c9 33:33:00:00:00:02 1
packet in 1 42:c4:dc:ec:a5:89 33:33:00:00:00:16 1
packet in 1 42:c4:dc:ec:a5:89 33:33:00:00:00:02 1
packet in 2 42:c4:dc:ec:a5:89 33:33:00:00:00:16 1
packet in 2 42:c4:dc:ec:a5:89 33:33:00:00:00:02 1
packet in 1 7e:05:35:16:79:3a 33:33:00:00:00:16 2
packet in 1 7e:05:35:16:79:3a 33:33:00:00:00:02 2
packet in 2 7e:05:35:16:79:3a 33:33:00:00:00:16 1
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packet in 2 e6:38:3b:ca:29:9b 33:33:00:00:00:16 1
packet in 1 ea:ba:86:81:30:b2 33:33:00:00:00:16 4
packet in 1 ea:ba:86:81:30:b2 33:33:00:00:00:02 4
packet in 1 ea:ba:86:81:30:b2 33:33:00:00:00:16 4
packet in 2 e6:38:3b:ca:29:9b 33:33:00:00:00:fb 1
packet in 2 e6:38:3b:ca:29:9b 33:33:00:00:00:fb 1
packet in 1 56:ac:11:23:90:c9 33:33:00:00:00:16 3
packet in 2 56:ac:11:23:90:c9 33:33:00:00:00:16 1
packet in 1 ea:ba:86:81:30:b2 33:33:00:00:00:fb 4
packet in 2 62:19:af:1c:29:0a 33:33:00:00:00:16 3
packet in 2 62:19:af:1c:29:0a 33:33:00:00:00:02 3
packet in 1 ea:ba:86:81:30:b2 33:33:00:00:00:fb 4
packet in 1 62:19:af:1c:29:0a 33:33:00:00:00:16 4
packet in 1 62:19:af:1c:29:0a 33:33:00:00:00:02 4
packet in 1 7e:05:35:16:79:3a 33:33:00:00:00:16 2
packet in 2 7e:05:35:16:79:3a 33:33:00:00:00:16 1
packet in 1 ea:ba:86:81:30:b2 33:33:00:00:00:16 4
packet in 2 e6:38:3b:ca:29:9b 33:33:00:00:00:fb 1
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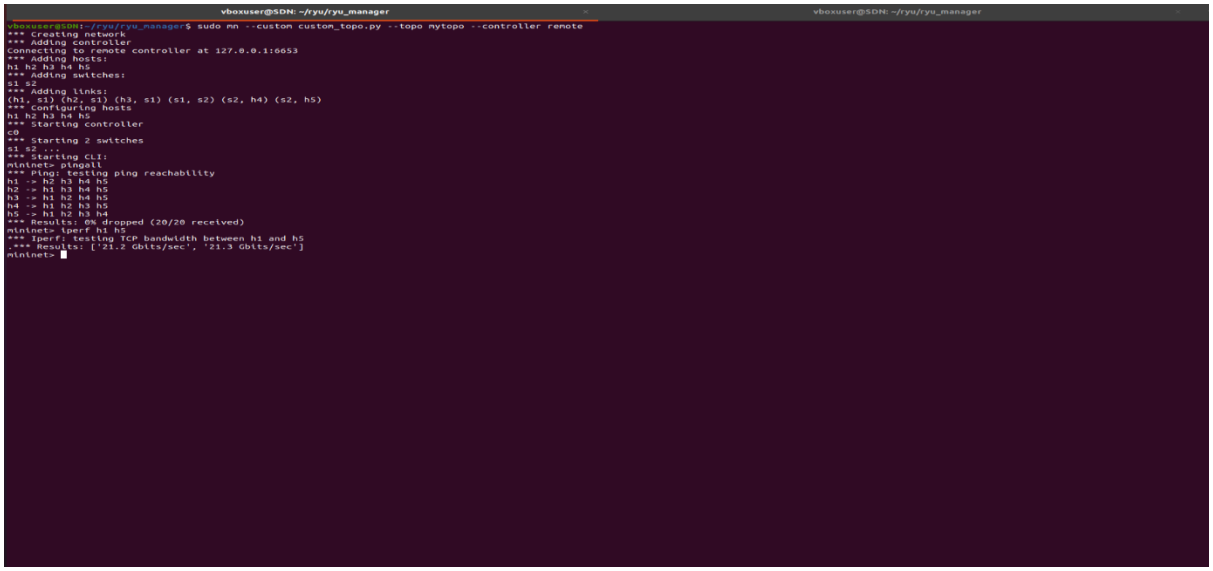
packet in 2 e6:38:3b:ca:29:9b 33:33:00:00:00:16 1
packet in 2 e6:38:3b:ca:29:9b 33:33:00:00:00:fb 1
packet in 1 ea:ba:86:81:30:b2 33:33:00:00:00:fb 4
packet in 2 e6:38:3b:ca:29:9b 33:33:00:00:00:fb 1
packet in 1 ea:ba:86:81:30:b2 33:33:00:00:00:fb 4
packet in 1 ea:ba:86:81:30:b2 33:33:00:00:00:16 4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vboxuser@SDN:~/ryu/ryu_manager$ sudo mn --custom custom_topo.py --topo mytopo --controller remote
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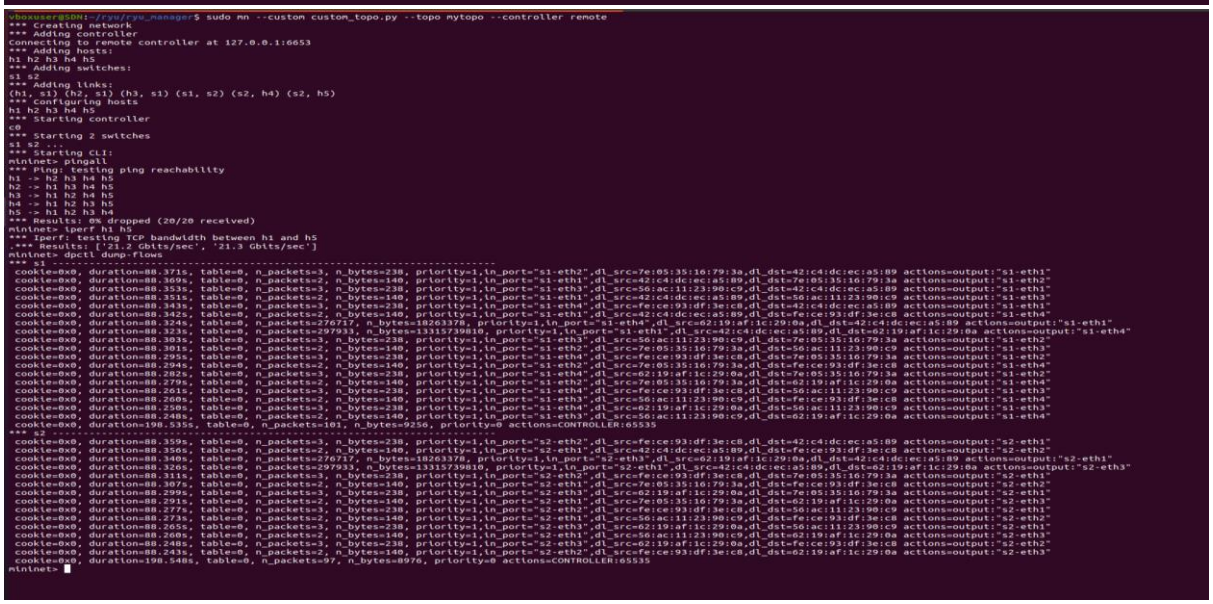
*** Adding controller
Connecting to remote controller at 127.0.0.1:6653
*** Adding hosts:
h1 h2 h3 h4 h5
*** Adding switches:
s1 s2
*** Adding links:
(h1, s1) (h2, s1) (h3, s1) (s1, s2) (s2, h4) (s2, h5)
*** Configuring hosts
h1 h2 h3 h4 h5
*** Starting controller
c0
*** Starting 2 switches
s1 s2 ...
*** Starting CLI:
mininet> pingall
*** Ping: testing ping reachability
h1 -> h2 h3 h4 h5
h2 -> h1 h3 h4 h5
h3 -> h1 h2 h4 h5
h4 -> h1 h2 h3 h5
h5 -> h1 h2 h3 h4
*** Results: 0% dropped (20/20 received)
mininet> iperf h1 h5
*** Iperf: testing TCP bandwidth between h1 and h5
*** Results: ['21.2 Gbits/sec', '21.3 Gbits/sec']
mininet>


vboxuser@SDN:~/ryu/ryu_manager$ sudo mn --custom custom_topo.py --topo mytopo --controller remote
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*** Adding links:
(h1, s1) (h2, s1) (h3, s1) (s1, s2) (s2, h4) (s2, h5)
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*** Ping: testing ping reachability
h1 -> h2 h3 h4 h5
h2 -> h1 h3 h4 h5
h3 -> h1 h2 h4 h5
h4 -> h1 h2 h3 h5
h5 -> h1 h2 h3 h4
*** Results: 0% dropped (20/20 received)
mininet> iperf h1 h5
*** Iperf: testing TCP bandwidth between h1 and h5
*** Results: ['21.2 Gbits/sec', '21.3 Gbits/sec']
mininet> dpctl dump-flows
*** s1 --
cookie=0x0, duration=88.371s, table=0, n_packets=3, n_bytes=238, priority=1,in_port="s1-eth2",dl_src=7e:05:35:16:79:3a,dl_dst=42:c4:dc:ec:a5:89 actions=output:"s1-eth1"
cookie=0x0, duration=88.369s, table=0, n_packets=2, n_bytes=140, priority=1,in_port="s1-eth1",dl_src=42:c4:dc:ec:a5:89,dl_dst=7e:05:35:16:79:3a actions=output:"s1-eth2"
cookie=0x0, duration=88.353s, table=0, n_packets=3, n_bytes=238, priority=1,in_port="s1-eth3",dl_src=56:ac:11:23:90:c9,dl_dst=42:c4:dc:ec:a5:89 actions=output:"s1-eth1"
cookie=0x0, duration=88.351s, table=0, n_packets=2, n_bytes=140, priority=1,in_port="s1-eth1",dl_src=42:c4:dc:ec:a5:89,dl_dst=56:ac:11:23:90:c9 actions=output:"s1-eth3"
cookie=0x0, duration=88.343s, table=0, n_packets=3, n_bytes=238, priority=1,in_port="s1-eth4",dl_src=fe:ce:93:df:3e:c8,dl_dst=42:c4:dc:ec:a5:89 actions=output:"s1-eth1"
cookie=0x0, duration=88.342s, table=0, n_packets=2, n_bytes=140, priority=1,in_port="s1-eth1",dl_src=42:c4:dc:ec:a5:89,dl_dst=fe:ce:93:df:3e:c8 actions=output:"s1-eth4"
cookie=0x0, duration=88.324s, table=0, n_packets=276717, n_bytes=18263378, priority=1,in_port="s1-eth4",dl_src=62:19:af:1c:29:0a,dl_dst=42:c4:dc:ec:a5:89 actions=output:"s1-eth1"
cookie=0x0, duration=88.323s, table=0, n_packets=297933, n_bytes=13315739810, priority=1,in_port="s1-eth1",dl_src=42:c4:dc:ec:a5:89,dl_dst=62:19:af:1c:29:0a actions=output:"s1-eth4"
cookie=0x0, duration=88.303s, table=0, n_packets=3, n_bytes=238, priority=1,in_port="s1-eth3",dl_src=56:ac:11:23:90:c9,dl_dst=7e:05:35:16:79:3a actions=output:"s1-eth2"
cookie=0x0, duration=88.301s, table=0, n_packets=2, n_bytes=140, priority=1,in_port="s1-eth2",dl_src=7e:05:35:16:79:3a,dl_dst=56:ac:11:23:90:c9 actions=output:"s1-eth3"
cookie=0x0, duration=88.295s, table=0, n_packets=3, n_bytes=238, priority=1,in_port="s1-eth4",dl_src=fe:ce:93:df:3e:c8,dl_dst=7e:05:35:16:79:3a actions=output:"s1-eth2"
cookie=0x0, duration=88.294s, table=0, n_packets=2, n_bytes=140, priority=1,in_port="s1-eth2",dl_src=7e:05:35:16:79:3a,dl_dst=fe:ce:93:df:3e:c8 actions=output:"s1-eth4"
cookie=0x0, duration=88.282s, table=0, n_packets=3, n_bytes=238, priority=1,in_port="s1-eth4",dl_src=62:19:af:1c:29:0a,dl_dst=7e:05:35:16:79:3a actions=output:"s1-eth2"
cookie=0x0, duration=88.279s, table=0, n_packets=2, n_bytes=140, priority=1,in_port="s1-eth2",dl_src=7e:05:35:16:79:3a,dl_dst=62:19:af:1c:29:0a actions=output:"s1-eth4"
cookie=0x0, duration=88.261s, table=0, n_packets=3, n_bytes=238, priority=1,in_port="s1-eth4",dl_src=fe:ce:93:df:3e:c8,dl_dst=56:ac:11:23:90:c9 actions=output:"s1-eth3"
cookie=0x0, duration=88.260s, table=0, n_packets=2, n_bytes=140, priority=1,in_port="s1-eth3",dl_src=56:ac:11:23:90:c9,dl_dst=fe:ce:93:df:3e:c8 actions=output:"s1-eth4"
cookie=0x0, duration=88.250s, table=0, n_packets=3, n_bytes=238, priority=1,in_port="s1-eth4",dl_src=62:19:af:1c:29:0a,dl_dst=56:ac:11:23:90:c9 actions=output:"s1-eth3"
cookie=0x0, duration=88.248s, table=0, n_packets=2, n_bytes=140, priority=1,in_port="s1-eth3",dl_src=56:ac:11:23:90:c9,dl_dst=62:19:af:1c:29:0a actions=output:"s1-eth4"
cookie=0x0, duration=198.535s, table=0, n_packets=101, n_bytes=9256, priority=0 actions=CONTROLLER:65535
*** s2 --
cookie=0x0, duration=88.359s, table=0, n_packets=3, n_bytes=238, priority=1,in_port="s2-eth2",dl_src=fe:ce:93:df:3e:c8,dl_dst=42:c4:dc:ec:a5:89 actions=output:"s2-eth1"
cookie=0x0, duration=88.356s, table=0, n_packets=2, n_bytes=140, priority=1,in_port="s2-eth1",dl_src=42:c4:dc:ec:a5:89,dl_dst=fe:ce:93:df:3e:c8 actions=output:"s2-eth2"
cookie=0x0, duration=88.340s, table=0, n_packets=276717, n_bytes=18263378, priority=1,in_port="s2-eth3",dl_src=62:19:af:1c:29:0a,dl_dst=42:c4:dc:ec:a5:89 actions=output:"s2-eth1"
cookie=0x0, duration=88.326s, table=0, n_packets=297933, n_bytes=13315739810, priority=1,in_port="s2-eth1",dl_src=42:c4:dc:ec:a5:89,dl_dst=62:19:af:1c:29:0a actions=output:"s2-eth3"
cookie=0x0, duration=88.311s, table=0, n_packets=3, n_bytes=238, priority=1,in_port="s2-eth2",dl_src=fe:ce:93:df:3e:c8,dl_dst=7e:05:35:16:79:3a actions=output:"s2-eth3"
cookie=0x0, duration=88.307s, table=0, n_packets=2, n_bytes=140, priority=1,in_port="s2-eth1",dl_src=7e:05:35:16:79:3a,dl_dst=fe:ce:93:df:3e:c8 actions=output:"s2-eth2"
cookie=0x0, duration=88.299s, table=0, n_packets=3, n_bytes=238, priority=1,in_port="s2-eth3",dl_src=62:19:af:1c:29:0a,dl_dst=7e:05:35:16:79:3a actions=output:"s2-eth1"
cookie=0x0, duration=88.291s, table=0, n_packets=2, n_bytes=140, priority=1,in_port="s2-eth1",dl_src=7e:05:35:16:79:3a,dl_dst=62:19:af:1c:29:0a actions=output:"s2-eth3"
cookie=0x0, duration=88.277s, table=0, n_packets=3, n_bytes=238, priority=1,in_port="s2-eth2",dl_src=fe:ce:93:df:3e:c8,dl_dst=56:ac:11:23:90:c9 actions=output:"s2-eth1"
cookie=0x0, duration=88.273s, table=0, n_packets=2, n_bytes=140, priority=1,in_port="s2-eth1",dl_src=56:ac:11:23:90:c9,dl_dst=fe:ce:93:df:3e:c8 actions=output:"s2-eth2"
cookie=0x0, duration=88.265s, table=0, n_packets=3, n_bytes=238, priority=1,in_port="s2-eth3",dl_src=62:19:af:1c:29:0a,dl_dst=56:ac:11:23:90:c9 actions=output:"s2-eth1"
cookie=0x0, duration=88.260s, table=0, n_packets=2, n_bytes=140, priority=1,in_port="s2-eth1",dl_src=56:ac:11:23:90:c9,dl_dst=62:19:af:1c:29:0a actions=output:"s2-eth3"
cookie=0x0, duration=88.248s, table=0, n_packets=3, n_bytes=238, priority=1,in_port="s2-eth3",dl_src=62:19:af:1c:29:0a,dl_dst=fe:ce:93:df:3e:c8 actions=output:"s2-eth2"
cookie=0x0, duration=88.243s, table=0, n_packets=2, n_bytes=140, priority=1,in_port="s2-eth2",dl_src=fe:ce:93:df:3e:c8,dl_dst=62:19:af:1c:29:0a actions=output:"s2-eth3"
cookie=0x0, duration=198.548s, table=0, n_packets=97, n_bytes=8976, priority=0 actions=CONTROLLER:65535
mininet>

Hub

The provided code is a Ryu application implementing a simple OpenFlow 1.3 switch. Below is a summary of the code's functionality and potential improvements:

Functionality:

Initialization:

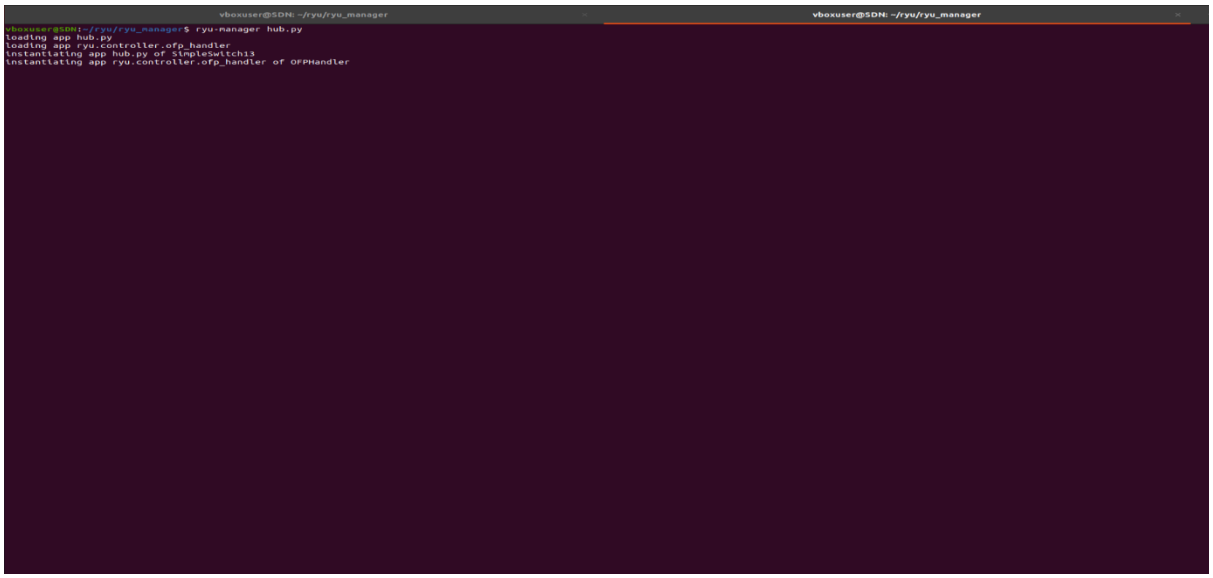
The application initializes a dictionary (mac_to_port) to store MAC addresses and corresponding switch ports.

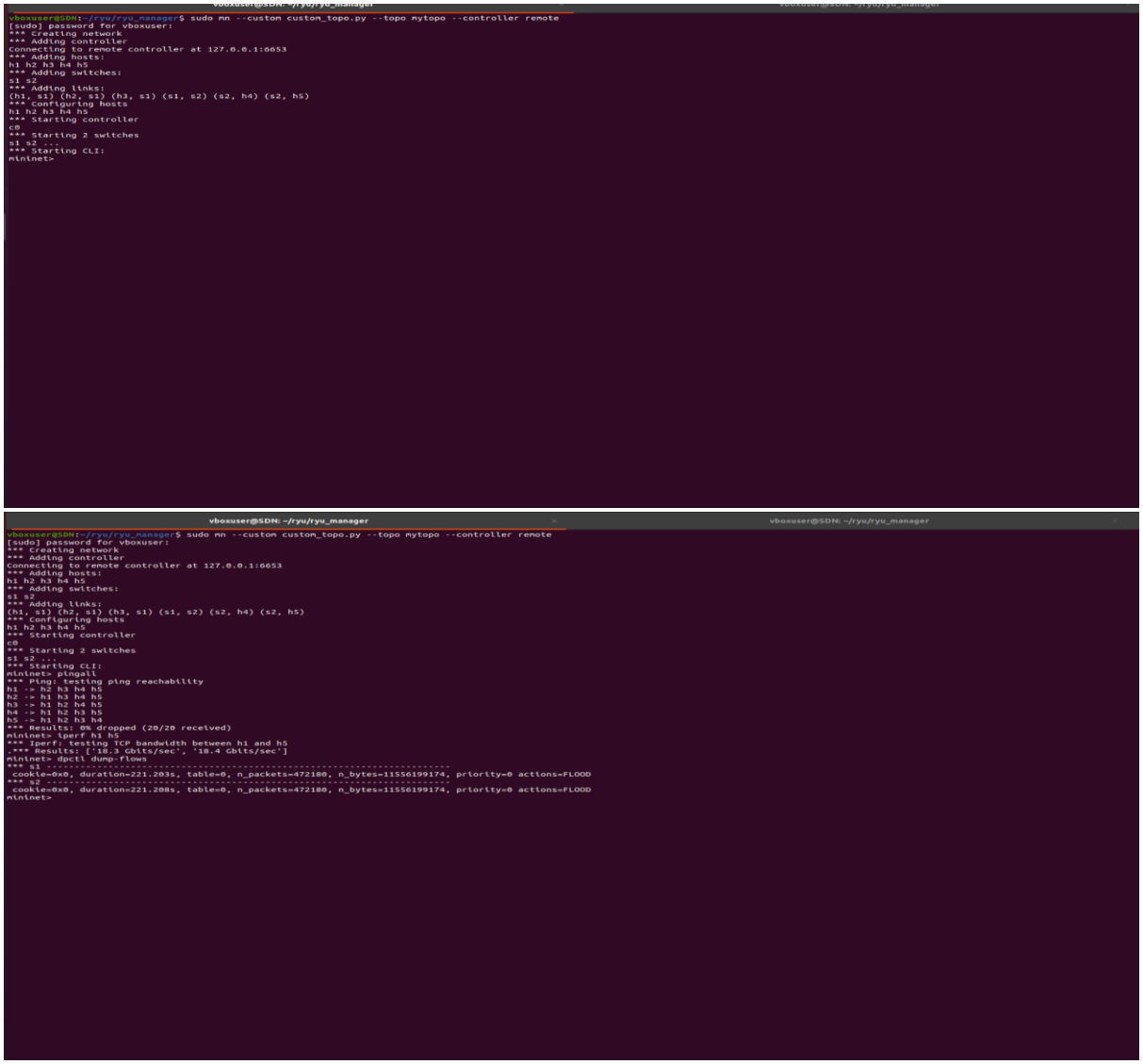
switch_features_handler:

When a switch connects, this handler is called to configure the switch to send unmatched packets to the controller for processing.It sets up a default flow entry to flood incoming packets to all ports.

packet_in_handler:Handles incoming packets that are not in the switch's flow table.Learns MAC addresses and associated input ports.Determines the output port for each packet based on the destination MAC address.If the destination is known, it installs a flow entry to forward similar packets without controller intervention.If the destination is unknown, it floods the packet to all ports except the input port.

attached screenshot





Load balancer

The provided Ryu application is a Layer 2 and Layer 3 switch that handles ARP requests and TCP packets with load balancing functionality between two servers. Below is a report on its functionality and potential improvements:

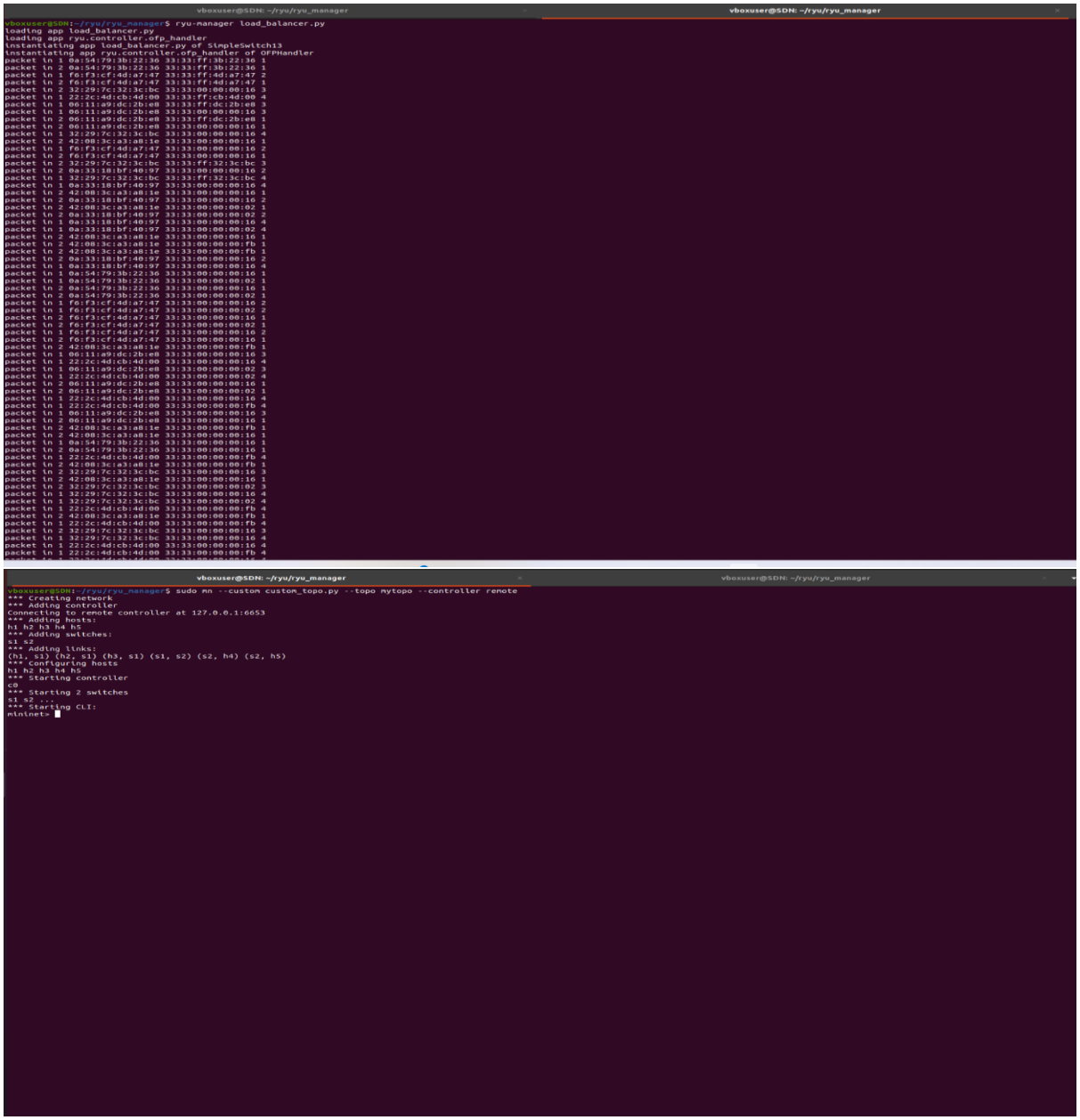
Functionality:

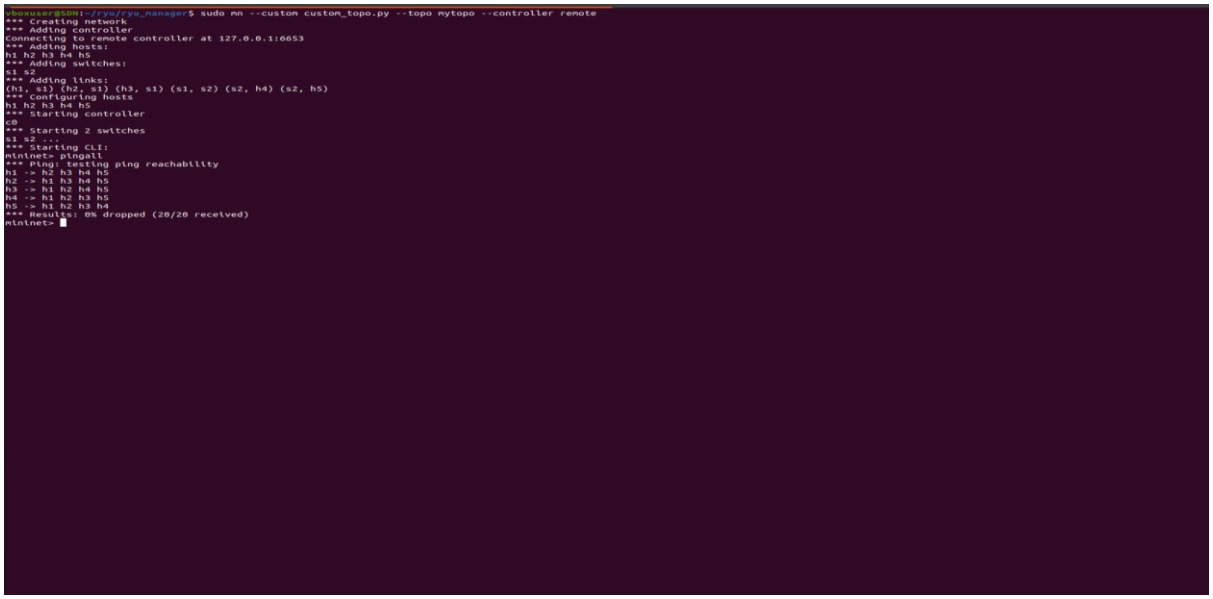
Initialization:The application initializes a dictionary (mac_to_port) to store MAC addresses and corresponding switch ports.It configures the switch to send unmatched packets to the controller for processing.

Packet-In Handler (_packet_in_handler):Processes incoming packets, including ARP requests and TCP packets.

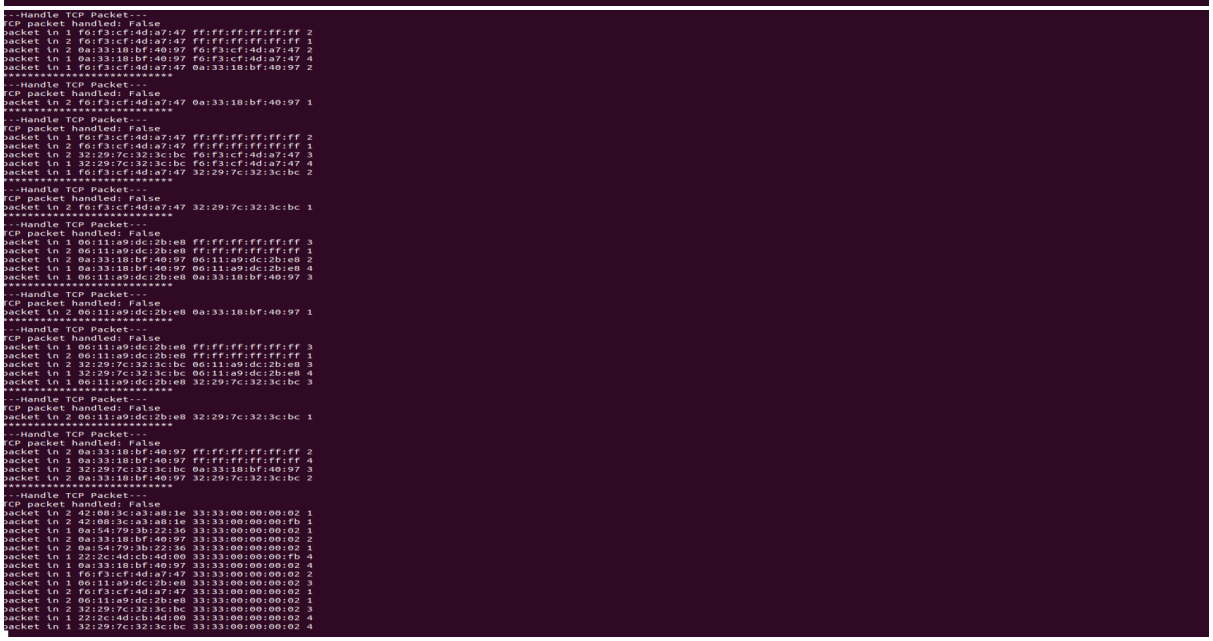
Learns MAC addresses and associated input ports.Handles ARP requests for a virtual IP (VIRTUAL_IP) by generating ARP reply packets based on the MAC address of the corresponding server.Routes TCP packets destined for the virtual IP to one of the two servers (SERVER1_IP or SERVER2_IP) based on the destination MAC address.Sets up flow entries in the switch to forward packets between the client and the selected server.Implements basic load balancing by choosing a server based on the parity of the client's MAC address.

Attached Screenshot:

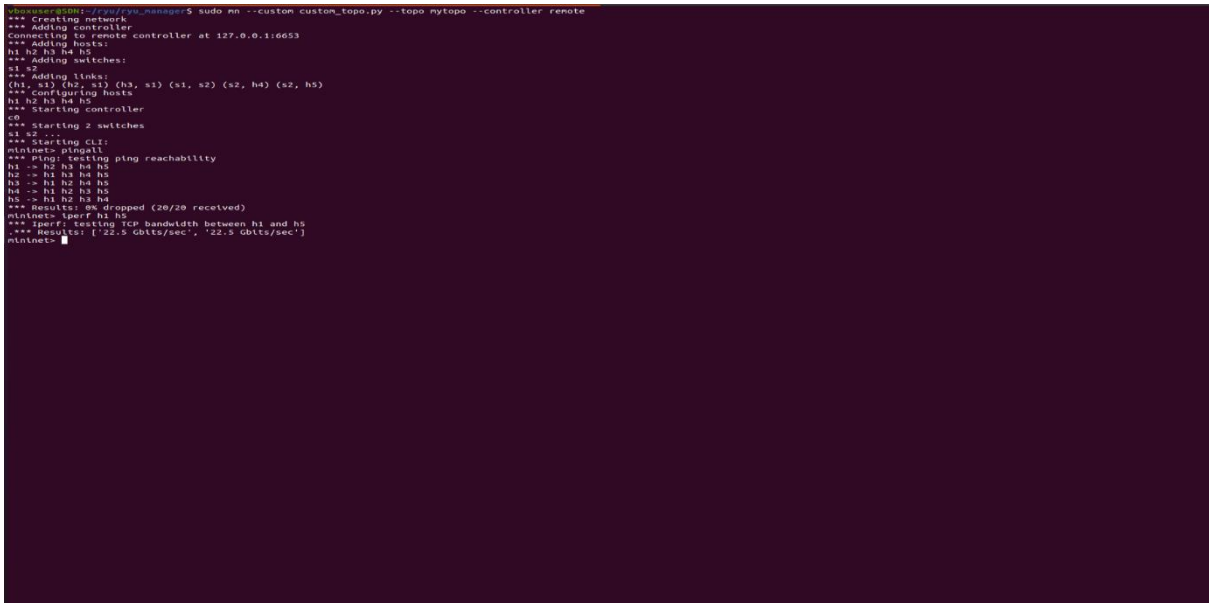


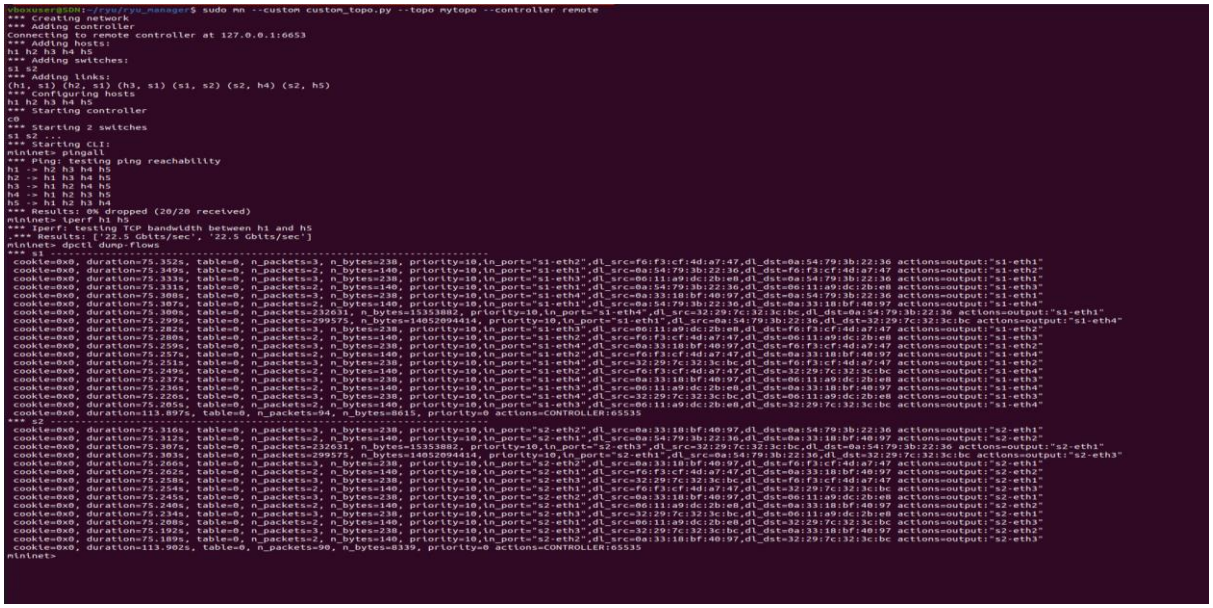


```
vboxuser@SDN:~/ryu/ryu_manager$ sudo mn --custom custom_topo.py --topo mytopo --controller remote
*** Creating network
*** Adding controller
Connecting to remote controller at 127.0.0.1:6653
*** Adding hosts:
h1 h2 h3 h4 h5
*** Adding switches:
s1 s2
*** Adding links:
(h1, s1) (h2, s1) (h3, s1) (s1, s2) (s2, h4) (s2, h5)
*** Configuring hosts
h1 h2 h3 h4 h5
*** Starting controller
c0
*** Starting 2 switches
s1 s2 ...
*** Starting CLI:
mininet> pingall
*** Ping: testing ping reachability
h1 -> h2 h3 h4 h5
h2 -> h1 h3 h4 h5
h3 -> h1 h2 h4 h5
h4 -> h1 h2 h3 h5
h5 -> h1 h2 h3 h4
*** Results: 0% dropped (20/20 received)
mininet>
```



```
---Handle TCP Packet---
TCP packet handled: False
packet in 1 f6:f3:cf:4d:a7:47 ff:ff:ff:ff:ff:ff 2
packet in 2 f6:f3:cf:4d:a7:47 ff:ff:ff:ff:ff:ff 1
packet in 2 0a:33:18:bf:40:97 f6:f3:cf:4d:a7:47 2
packet in 1 0a:33:18:bf:40:97 f6:f3:cf:4d:a7:47 4
packet in 1 f6:f3:cf:4d:a7:47 0a:33:18:bf:40:97 2
**************************
---Handle TCP Packet---
TCP packet handled: False
packet in 2 f6:f3:cf:4d:a7:47 0a:33:18:bf:40:97 1
**************************
---Handle TCP Packet---
TCP packet handled: False
packet in 1 f6:f3:cf:4d:a7:47 ff:ff:ff:ff:ff:ff 2
packet in 2 f6:f3:cf:4d:a7:47 ff:ff:ff:ff:ff:ff 1
packet in 2 32:29:7c:32:3c:bc f6:f3:cf:4d:a7:47 3
packet in 1 32:29:7c:32:3c:bc f6:f3:cf:4d:a7:47 4
packet in 1 f6:f3:cf:4d:a7:47 32:29:7c:32:3c:bc 2
**************************
---Handle TCP Packet---
TCP packet handled: False
packet in 2 f6:f3:cf:4d:a7:47 32:29:7c:32:3c:bc 1
**************************
---Handle TCP Packet---
TCP packet handled: False
packet in 1 06:11:a9:dc:2b:e8 ff:ff:ff:ff:ff:ff 3
packet in 2 06:11:a9:dc:2b:e8 ff:ff:ff:ff:ff:ff 1
packet in 2 0a:33:18:bf:40:97 06:11:a9:dc:2b:e8 2
packet in 1 0a:33:18:bf:40:97 06:11:a9:dc:2b:e8 4
packet in 1 06:11:a9:dc:2b:e8 0a:33:18:bf:40:97 3
**************************
---Handle TCP Packet---
TCP packet handled: False
packet in 2 06:11:a9:dc:2b:e8 0a:33:18:bf:40:97 1
**************************
---Handle TCP Packet---
TCP packet handled: False
packet in 1 06:11:a9:dc:2b:e8 ff:ff:ff:ff:ff:ff 3
packet in 2 06:11:a9:dc:2b:e8 ff:ff:ff:ff:ff:ff 1
packet in 2 32:29:7c:32:3c:bc 06:11:a9:dc:2b:e8 3
packet in 1 32:29:7c:32:3c:bc 06:11:a9:dc:2b:e8 4
packet in 1 06:11:a9:dc:2b:e8 32:29:7c:32:3c:bc 3
**************************
---Handle TCP Packet---
TCP packet handled: False
packet in 2 06:11:a9:dc:2b:e8 32:29:7c:32:3c:bc 1
**************************
---Handle TCP Packet---
TCP packet handled: False
packet in 2 0a:33:18:bf:40:97 ff:ff:ff:ff:ff:ff 2
packet in 1 0a:33:18:bf:40:97 ff:ff:ff:ff:ff:ff 4
packet in 2 32:29:7c:32:3c:bc 0a:33:18:bf:40:97 3
packet in 2 0a:33:18:bf:40:97 32:29:7c:32:3c:bc 2
**************************
---Handle TCP Packet---
TCP packet handled: False
packet in 2 42:08:3c:a3:a8:1e 33:33:00:00:00:02 1
packet in 2 42:08:3c:a3:a8:1e 33:33:00:00:00:fb 1
packet in 1 0a:54:79:3b:22:36 33:33:00:00:00:02 1
packet in 2 0a:33:18:bf:40:97 33:33:00:00:00:02 2
packet in 2 0a:54:79:3b:22:36 33:33:00:00:00:02 1
packet in 1 22:2c:4d:cb:4d:00 33:33:00:00:00:fb 4
packet in 1 0a:33:18:bf:40:97 33:33:00:00:00:02 4
packet in 1 f6:f3:cf:4d:a7:47 33:33:00:00:00:02 2
packet in 1 06:11:a9:dc:2b:e8 33:33:00:00:00:02 3
packet in 2 f6:f3:cf:4d:a7:47 33:33:00:00:00:02 1
packet in 2 06:11:a9:dc:2b:e8 33:33:00:00:00:02 1
packet in 2 32:29:7c:32:3c:bc 33:33:00:00:00:02 3
packet in 1 22:2c:4d:cb:4d:00 33:33:00:00:00:02 4
packet in 1 32:29:7c:32:3c:bc 33:33:00:00:00:02 4
```





Firewall

The provided Ryu application acts as a simple firewall, allowing or blocking traffic based on predefined rules. The application uses OpenFlow protocol version 1.3.

Initialization:

The application initializes a dictionary (mac_to_port) to store MAC addresses and corresponding switch ports.It configures the switch to send unmatched packets to the controller for processing.

Packet-In Handler (_packet_in_handler):Processes incoming packets and checks them against predefined firewall rules.Filters out LLDP packets.Learns MAC addresses and associated input ports.Implements basic firewall rules for allowing or blocking traffic based on source and destination MAC addresses.

Firewall Rules:

Allow Rule:

Allows traffic from MAC address ALLOW_MAC to any destination. Adds a flow entry for the allowed traffic. Logs the allowed packet and port information.

Block Rule:
Blocks traffic from MAC address BLOCK_MAC to any destination.Does not add a flow entry for blocked traffic.Logs the blocked packet and port information.